Continuing Education Questionnaire, page 1256
Meets learning need codes 3010, 3020, and 3090

Personality characteristics as predictors of underreporting of energy intake on 24-hour dietary recall interviews

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ABSTRACT

Objective To identify characteristics associated with misreporting of energy intake during 24-hour dietary recalls (24HR).

Design Ninety-eight subjects were administered two 24HRs. Energy expenditure was determined by doubly labeled water (44 subjects) or intake balance (54 subjects). Data on subjects' physical, lifestyle, and psychosocial characteristics were also collected.

Subjects/setting At the Beltsville Human Nutrition Research Center 52 women and 46 men were administered 24HR and completed lifestyle and personality questionnaires and a memory test. Physical characteristics such as weight, percent body fat, and total energy expenditure were measured.

Statistical analysis The influences of subject parameters on energy misreporting were assessed by linear regression and Pearson product-moment correlation analysis for continuous variables and by ANOVA for discrete variables. Stepwise regression was used to identify key factors in underreporting.

Results Factors particularly important in predicting underreporting of energy intake include factors indicating dissatisfaction with body image; for example, a 398 kcal/day underreport in subjects attempting weight loss during the past year with a nearly 500 kcal/day underreport in women. Overall, women underreported by 393 kcal/day relative to men and women evinced a social desirability bias amounting to a 26 kcal underreport for each point on the social desirability scale. Gender differences also were evident in the effect of percent body fat (with men underreporting about 16 kcal/day/percent body fat) and in departure from self-reported ideal body weight (with women underreporting about 21 kcal/day/kg).

Applications/conclusions Body image and fatness are key factors on which health professionals should focus when seeking predictors of underreporting of dietary intake. Dietary interviews must be conducted to minimize bias related to subjects' tendencies to win approval and avoid censure by the interviewer. In addition, dissatisfaction with body image may lead to underestimation of food intake, therefore reducing likelihood of success in weight loss. Thus, health care professionals involved in weight loss counseling may achieve better success if treatment includes generating a more positive body image. *J Am Diet Assoc. 2003;103:1146-1151.*

Dietary assessment tools are critical for assessing dietary intake, knowledge of which is crucial for planning programs for nutrition education. The 24-hour dietary recall interview (24HR) is used as the assessment method of choice for large surveys conducted in the United States (1-

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0002-8223/03/10309-0002$30.00/0
doi: 10.1053/jada.2003.50568

3). Such surveys provide the data necessary to guide policy to improve the health of Americans. Many studies have shown that substantial underreporting occurs for various methods of dietary intake assessment (4-20). Further, underreporting has been observed in many segments of the populations, including both men and women (18) and occurring across a wide age range (12).

Given the importance of the 24HR in assessing the dietary intake of the US population, understanding sources of error will assist in guiding nutrition education policy (3,21-23). Further, identifying persons who are likely to underestimate food intake may help to pinpoint those who are at risk for developing obesity or who may have particular difficulty in reducing body weight, as these persons clearly are less aware of their energy intake.

In this study we compare dietary energy intake by 24HR intake against doubly labeled water or intake balance measurement of energy expenditure in a sample of adults. Our study investigates a population that is very heterogeneous in physical and demographic characteristics, and we have assessed the issue of body image. The measurement of a wide range of subject characteristics and lifestyle parameters has allowed identification of predictors of underreporting for the 24HR.

METHODS

Between January and April 1997, 98 healthy adult volunteers (52 women and 46 men, aged 25 to 73 years) from the Beltsville, MD, area participated in this study. Recruitment information was distributed to subjects who had participated in previous studies at the Beltsville Human Nutrition Research Center and to the 1,500 employees of the Beltsville Agricultural Research Center. Subjects completed a brief questionnaire related to health status, job-related physical activity, exercise routine, leisure time physical activity, recent weight reduction attempts or change in body weight, recent change in smoking status, and physical injuries (that may have affected physical activity). Based on the questionnaire, subjects who were determined to have had changes in physical activity, smoking status, body weight, or dietary intake (including attempts at weight reduction) during the past six months were excluded from the study. Also, women who were currently pregnant or had been pregnant during the past 12 months were excluded from the study. The study protocol was approved by the Johns Hopkins University Bloomberg School of Public Health Committee on Human Research, and written consent was obtained from each subject before measurements began.

Subjects' body weights were measured to the nearest 0.1 kg using a calibrated electronic scale. Height was measured to the nearest 0.1 cm by using a stationary inflexible measuring tape and head board. Body composition was measured by dual-energy x-ray absorptiometry (Hologic Inc, Bedford, MA), a method by which photons at two energies are transmitted through the body, and the rates of transmission provide information about tissue density and body composition (24).

Energy requirement for subjects was determined by one of two methods: the doubly labeled water method (44 subjects), or the intake balance method (54 subjects). These two methods have been shown to result in energy requirement values that agree within 0.3% in our laboratory (25). For the intake balance method (18), subjects consumed a prescribed diet to maintain body weight (as part of an independent controlled feeding study), and the energy content of this diet was then assumed to equal the average energy expenditure. For subjects participating in controlled feeding studies, the dietary recall interviews were conducted approximately two weeks before the controlled feeding period began. Therefore subjects were not participating in a feeding study during their dietary interviews. The controlled diets were administered as weight-maintenance diet composition studies lasting at least 12 weeks. During the controlled feeding period, subjects ate only foods prepared by the Beltsville Human Nutrition Research Center, and subjects were weighed daily. Diet compositions and energy intakes during this time were calculated by a registered dietician using Nutritionist IV (version 2.0, 1995, First Databank, San Bruno, CA). Each week, the subjects' weights were reviewed and energy intakes were altered in increments of 200 kcal/day to achieve weight maintenance. The first four weeks of the controlled feeding period were not included in the calculation of weight-maintenance energy intake so that the initial adjustment period would not adversely affect the results. Total energy expenditure was considered to be the average daily dietary energy level during the eight-week weight maintenance period after the first four weeks of controlled feeding.

For the subjects not participating in a controlled diet study at the Beltsville Human Nutrition Research Center, total daily energy expenditure was measured by the doubly labeled water method (26). Subjects reported to the Beltsville Human Nutrition Research Center between 6:30 AM and 9:00 AM, at which time they received an oral dose of $H_2{}^{18}O$ (0.12 g/kg body weight) and ^2H_2O (0.55 g/kg body weight). Urine samples were collected immediately before the dose and on days 1, 2, 3, 12, 13, and 14 after the dose. Subjects recorded the specific time of sample collection on each of those days. Enrichment of ^2H and ^{18}O in urine samples was measured by infrared spectroscopy (MIRAN 1A-FF, Foxboro/Wilks Inc, S Norwalk, CT) and isotope ratio mass spectrometry (Europa, Cheshire, England), respectively. The total energy expenditure was calculated from the ^2H and ^{18}O decay kinetics as described by Schoeller (26).

Social desirability was measured using the Marlowe-Crowne Social Desirability scale. Those 33 true/false questions quantify a tendency to avoid criticism and to defend one's social image in a testing situation, portraying oneself as conforming to societal expectations (27). In contrast to social desirability, social approval is the tendency for a person to seek a positive response in testing situations and, therefore, is less focused on defensiveness (28). The Martin-Larsen Approval Motivation scale consists of 20 questions, each requiring a response ranging from disagree strongly to agree strongly. Items are rated on a five-point scale. The sum of the individual response scores is the social approval score. Scores from Martin-Larsen Approval Motivation scale and the Marlowe-Crowne Social Desirability scale are virtually uncorrelated (7,10), and both have been found to bias dietary self-assessments in previous work (10,29,30).

Subjects were given a word list memory test to see if memory was correlated to level of misreporting. The memory test consisted of 10 nouns: gold, car, fox, earth, rod, jail, prayer, odor, settler, and brain. These words randomly selected from a list of 925 nouns to fit the following criteria: $\leq$8 letters; 1 to 2 syllables; $\geq$20 occurrences per million words; balanced in rating for concreteness, imagery, and meaningfulness; unrelated to foods or measuring utensils; all beginning with different letters; and from different taxonomic categories (31). The words were presented on flashcards sequentially to subjects for three seconds each. Subjects were then instructed to count aloud backward from 40, and were stopped when they reached 25. Subjects

were then asked to recall as many words as possible. The subject's score was equal to the number of words correctly remembered. Incorrect word recollections were not entered into the score.

A lifestyle questionnaire was administered to all subjects. Each subject completed the questionnaire in a quiet room free of distractions. The questionnaire covered the following information: self-reported height and weight, weight at 25 years old, highest weight achieved to date, age, marital status, daily sleeping and eating schedules, hours watching television, consumption of alcoholic beverages, and exercise and leisure-time activity patterns. To determine exercise and leisure time physical activity patterns, we asked the subjects whether they participate in the following activities: walking, jogging/running, bicycling/riding an exercise bike, swimming, aerobics, dancing, calisthenics, yard work, or weight lifting. They were also able to enter other activities. For each activity, the subject entered the frequency of the activity and the duration.

The questionnaire probed body image by asking the following questions, each of which was scored independently: Would you like to weigh more, less, or stay the same? (subjects were categorized into two groups; because only two subjects answered "weigh more," the "weigh more" group was combined with the "stay the same" group. Thus those subjects who chose "weigh less" were compared to those who answered otherwise); Are you overweight, underweight, or the right weight? (subjects were categorized into two groups; because only two people answered "underweight," the "underweight" group was combined with the "right weight" group. Thus those who answered "overweight" were compared to those who answered otherwise); Have you attempted weight loss in the past 12 months? (this was a simple dichotomy of "yes" or "no"); and What is your ideal body weight? From the self-reported ideal body weight and the measured body weight, the difference between ideal weight and actual weight was calculated.

The dietary interviews were conducted by a registered dietitian trained at the University of Minnesota's Nutrition Coordinating Center to conduct 24HR using the Dietary Data Collection system (21) used in the third National Health and Nutrition Examination Survey (22). This recall method is a triple-pass method. The recall begins with the subjects compiling a quick list of food items eaten on the previous day, followed by an in-depth description of each food listed, and completed by a final review of foods and descriptions. An early version of the multiple-pass method as used in the US Department of Agriculture's National Survey Continuing Survey of Food Intakes by Individuals 1994-1996 and 1998, and was developed based on cognitive research conducted by the Census Bureau's Center for Survey Methods Research. A summary of the research and other questionnaire development activities is found in Guenther and colleagues (32). Each subject was interviewed twice; the second interview was conducted between 3 and 10 days after the first interview.

The nutrient composition data for the foods reported during the interviews were generated using the University of Minnesota Nutrient Database (versions 15 to 25, 1996, University of Minnesota, Nutrition Coordinating Center, Minneapolis). A comprehensive description of the third National Nutrition and Health Examination Survey dietary data collection and processing procedures and the Dietary Data Collection system is available on CD-ROM (33).

For each subject, the energy content of the two 24HRs were averaged and compared to his/her measured energy expenditure. The difference between measured energy expenditure and reported energy intake was considered the quantitative level of misreporting of energy intake.

Table 1
Characteristics of subjects

Characteristic	Mean±SD	Minimum	Maximum
Women			
Height (cm)	164.3±5.4	154.1	175.0
Weight (kg)	73.4±18.1	43.4	137.6
Age (y)	47.9±10.6	25.0	73.0
BMI (kg/m^2)	26.5±4.8	16.1	48.6
% Body fat	38.5±8.9	20.9	53.1
Energy discrepancy[a] (kcal/day)	−479*±548	−2,125	576
Men			
Height (cm)	177.9±6.7	166.4	195.9
Weight (kg)	84.1±11.6	61.7	108.3
Age (y)	47.1±10.0	27.0	65.0
BMI (kg/m^2)	27.4±5.6	20.0	34.3
% Body fat	24.0±6.7	10.6	43.5
Energy discrepancy[a] (kcal/day)	−86±803	−1,514	2,964

BMI=Body mass index.
SD=Standard deviation.
[a]Energy discrepancy between reported energy intake and measured energy requirement. A negative value indicates that reported energy intake was less than measured energy requirement.
*Statistically significantly different from zero at $P<.001$.

STATISTICS

Reported energy intake was compared to energy expenditure by paired t test. Linear regression and Pearson product-moment correlation analyses were performed to relate measured variables singly to the difference between 24HR energy intake and energy expenditure. The statistical significance of categorical variables on the difference between 24HR energy intake and energy expenditure was determined by ANOVA. Stepwise forward and backward regression techniques (with initial inclusion of all variables) were used to identify plausible factors most strongly associated with energy misreporting. Statistical tests were first performed on data stratified by method of assessment of energy requirement (doubly labeled water vs intake balance), and when the stratum-specific results did not differ, the data sets were combined. All statistics were performed using the Jandel Sigmastat software (version 2.03, 1997, SPSS Science, Chicago, IL).

RESULTS

The physical characteristics of the subjects are shown in Table 1. The men were, on average, 178 cm in height, 84 kg in weight, 24% body fat, and 47 years of age. The women were, on average, 164 cm in height, 73 kg in weight, 39% body fat, and 48 years of age.

For the study population as a whole, energy expenditure differed from reported energy intake by −294 kcal/day ($P\leq.001$). When subjects were divided by gender, the energy discrepancy remained statistically significant for women, but not for men. When compared by ANOVA, underreporting by women was of significantly larger magnitude than that of men.

When the underreporting was separated from the overreporting, it was found that 85% of the women underreported their energy intake (on average −621 kcal/day), whereas only

Table 2
Relationship between subject characteristics and the difference between energy expenditure as estimated by doubly labeled water or by intake balance and 24 hour recall-derived energy intake

Variables	Overall			Women			Men		
Continuous variables	**Mean±SD**	***r*[a]**	**β[b]**	**Mean±SD**	***r***	**β[b]**	**Mean±SD**	***r***	**β[b]**
Weight (kg)	78.4±16.3	0.03	1.3	73.4±18.1	−0.07	−2.2	84.1±11.6	−0.08	−5.5
BMI (kg/m^2)	26.9±5.2	0.03	4.4	26.5±4.8	0.18	20.9	27.4±5.6	−0.11	−15.7
Body Fat (%)	31.7±10.8	−0.24*	−15.7*	38.5±8.9	−0.02	−1.4	24.0±6.7	−0.13	−15.2
Age (y)	47.5±10.3	−0.01	−0.47	47.9±10.6	0.14	7.3	47.1±10.0	−0.11	−8.5
Social desirability	19.0±6.6	−0.06	−6.2	20.0±5.9	−0.28*	−26.4*	17.9±7.2	0.16	17.4
Social approval	35.6±8.8	0.01	1.1	35.5±9.1	0.26	15.5	35.6±8.6	−0.19	−17.7
Memory (words correct)	5.6±1.6	0.17	83.9	5.8±1.6	0.13	44.7	5.4±1.6	0.30	166.9
Weight 10 y ago (kg)	72.6±14.5	0.21*	10.3*	65.3±13.3	0.16	3.0	80.7±11.1	0.14	0.48
Weight at 25 y old (kg)	68.0±13.7	0.16	8.5	60.3±9.7	−0.11	−2.8	76.9±12.1	0.05	1.6
Yearly weight change since 25 y old (kg)	0.28±0.36	−0.09	−81.4	0.34±0.41	−0.09	−58.5	0.22±0.29	−0.003	−3.7
Weight change in past 10 y (kg)	6.2±9.7	−0.24*	−17.3*	8.2±11.3	−0.26	−13.0	3.9±7.1	−0.14	−16.4
Self-reported ideal body weight (kg)	69.3±12.2	0.18	10.6	61.0±8.3	−0.02	−0.57	78.6±8.6	0.001	0.030
Difference from ideal weight (kg)	4.5±4.9	−0.24*	−15.6*	6.18±5.58	−0.20	−8.2	2.7±3.2	−0.18	−20.6
Categorical variables	**Mean**		**β[b]**	**Mean**		**β[b]**	**Mean**		**β[b]**
Gender[c]	0.53		−392.5*						
Marital status[d]	0.63		−1.43	0.55		60.5	0.73		−276.6
"Attempted weight loss in past 12 mo?"[e]	0.37		−398.1*	0.50		−198.6	0.27		−499.4
"Are you overweight?"[e]	0.68		−303.7*	0.44		−77.8	0.61		−411.5
"Like to weigh less?"[e]	0.77		−338.9*	0.39		−54.0	0.46		−464.2

[a]Pearson Product Moment (parametric) correlation coefficient obtained in correlating the specified variable with the difference between 24 hour recall-derived estimate of energy intake and energy expenditure as estimated by doubly labeled water or by intake balance. Negative numbers indicate negative correlation, whereas positive numbers indicate positive correlation. Zero would indicate no correlation.
[b]The regression coefficient is obtained in regressing the specified variable with the difference between 24 hour recall-derived estimate of energy intake and energy expenditure as estimated by doubly labeled water or by direct measurement of intake balance.
[c]For statistical analysis, gender was coded as 1=woman and 0=man.
[d]For statistical analysis, marital status was coded as 1=married and 0=single, divorced, or widowed.
[e]For statistical analysis, an answer of Yes to these questions was coded as 1 and an answer of No was coded as 0.
*Statistically significant relationships at $P \leq .05$.

15% overreported their energy intake (on average +304 kcal/day). For men, 61% underreported their energy intake (on average −581 kcal/day), whereas 39% overreported their energy intake (on average +683 kcal/day).

Association of personal characteristics with energy misreporting is shown in Table 2. For males and females combined, energy misreporting was correlated with percent body fat (higher percent fat was associated with greater likelihood to underreport energy intake) and gender (women were more likely to underreport energy intake than men), but was correlated to no other physical characteristic measured.

Energy underreporting was correlated with measures of body image, including having attempted weight loss in the past 12 months (β=−389 kcal underreported for having attempted weight loss), difference in reported weight from self-designated ideal weight (β=−15.6 kcal underreported per kilogram above ideal weight), response to the question "Are you overweight, underweight, or the right weight?" (β=−303 kcal underreported for considering oneself overweight compared to answering otherwise), weight gain during the past 10 years (β=−17 kcal underreported per kg gained during the previous 10 years). Similarly, a predictor of energy intake misreporting was the response to the question "Would you like to weigh more, less, or stay the same?" (β=−338 kcal underreported for desiring to weigh less compared to answering otherwise). The difference between current weight and self-reported ideal weight was also a predictor of underreporting of energy (β=−15.6 kcal underreported for each kilogram above ideal weight).

For men only, the score of the memory recall test appeared to be a weak predictor of misreporting of energy intake (β=+167 kcal per word remembered correctly). For women only, the social desirability score was a predictor of energy

underreporting ($\beta = -26$ kcal underreported for each point on the social desirability scale).

Exploratory analyses of the whole study population by stepwise regression indicated that the most important factors related to underreporting of energy intake were difference from ideal body weight, memory, and attempting weight loss during the previous year. Coefficients for these factors had the highest statistical significance in the multiple regression analysis.

Among the parameters tested that were found to be unrelated to energy misreporting in this population were time spent exercising, sleep patterns, meal patterns, time watching television, consumption of alcohol, marital status, and highest body weight achieved. Smoking could not be evaluated properly because only eight of the subjects reported being smokers.

DISCUSSION

Dietary intake can be assessed by a variety of means, including 24HR, three-day or seven-day diet records, and a variety of structured assessment instruments, most commonly a food frequency questionnaire. In this study, we used the 24HR because of its importance in assessing food intake by the US population. The 24HR has been used by both the US Department of Health and Human Services and the US Department of Agriculture as a key tool for assessing US dietary patterns (3,21), using tools identical to those we employed here (21,22).

For this study, we used both the doubly labeled water method and the intake balance method to assess energy expenditure for comparison to reported energy intake. Doubly labeled water and intake balance provide a means of objective comparison important in assessing underreporting of energy intake by persons, rather than populations as a whole, and have been used to validate reported energy intake in past studies (6,8,14,15,18-20,25,34-36). The high cost of these methods limits the number of subjects that can be studied. Nonetheless, the sample size for this study was similar to or exceeded that of other intake validation studies (8,11,14,36,37).

Previous studies that investigated dietary intake underreporting show agreement in some areas and disagreement in others. Among the most dependable biasers are measures of overall adiposity, body fatness, and relative weight (5,35,38-43). Direct measures of adiposity are also consistently associated with underreporting (11,14,36,44). Although the preponderance of evidence indicates that relative weight [expressed as body mass index: weight(kg)/height(m)^2] (9,11,12,37,45) are biasers, not all of the evidence indicates an association (8). Consistent with the results of others, our study found body fatness to be related to underreporting, whereas body mass index and body weight were unrelated to underreporting in our population.

Gender has been related to underreporting in some, but not all, populations studied. Gender was found to be related to underreporting by Johnson and colleagues (14) and Goran and Poehlman (46), but not by Tomoyasu and associates (11), Black and colleagues (35), or Heitmann (44). Further, there are indications that the role of relative weight may be modified by gender (10), a finding consistent with views that body image and rates of dieting vary by gender (41,47,48). Our study found gender to be an important biaser, with women being much more prone to underreporting than men. This may be partially explained by the recent finding that when men and women are asked to describe the same foods, men often describe a more energy dense version than women (49).

This study also investigated social desirability and social approval, psychological trait measures that are known to bias responses on structured dietary assessment instruments (7,10,50). As in our previous work, we found differences by gender (10). For women, but not for men, social desirability scores were related to underreporting. This suggests that women, but not men, may have underreported food intake in an effort to defend themselves from being perceived as indulging in a behavior (eg, overeating) that is seen as socially undesirable. In contrast, there was an apparent (ie, marginally significant) effect of social approval in women but in the opposite direction (ie, associated with an overestimate). Of interest, this is what we have observed in men in earlier trials (10,29) as well as in women with less than a college education (30). Besides findings related to structured assessments, men have also been shown to respond differently from women on 24HR (50). Further, Wardle and Beales (51) showed that girls are particularly susceptible to diet-related guilt as early as their teen years, and this may motivate the social desirability bias.

Measures of body image were revealed as predictors of underreporting, including having attempted weight loss in the past year, self-designated ideal weight, the difference between current weight and self-designated ideal weight, and response to questions "Are you over-weight, under-weight, or about the right weight?" and "Would you like to weigh more, less, or stay the same?" Weight gain during the past 10 years was also found to be a predictor of underreporting in the population as a whole and also in women. However, weight gain since age 25 years was not found to be a predictor in the whole population or in either men or women. This may indicate that recent weight gain has a greater influence on body image than less recent weight gain. These measures of dissatisfaction with body weight and body image (and in the case of women, that dissatisfaction combined with the tendencies toward social desirability) reveal a likely cause of underreporting in dietary assessment. Moreover, these findings may indicate one reason for difficulty in weight-reduction and postreduction weight maintenance. If guilt and conflict associated with food intake are associated with underestimation of food intake (by one's unknowingly underestimating food frequencies, portion sizes, or both), then one might expect persons attempting weight loss to express this tendency to a relatively greater extent. Therefore, additional counseling related to both body image and nutrition may improve success of self-administered weight loss protocols.

APPLICATIONS

Body fatness and body image are key factors on which health care professionals should focus when seeking predictors of underreporting and when designing improvements to dietary assessment protocols. Further, dietary interviews must be conducted to minimize bias related to subjects' tendencies to win approval and avoid disapproval by the interviewer. In addition, dissatisfaction with body image may lead persons to underestimate food intake, therefore reducing likelihood of success of weight loss protocols. Thus, health care professionals involved in weight loss counseling may achieve better success if treatment includes generating a more positive body image.

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The authors thank Bethene Ervin for guidance in conducting the word memory test.